



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :

A62C 31/12, B05B 7/00

A1

(11) International Publication Number:

WO 97/38757

(43) International Publication Date:

23 October 1997 (23.10.97)

(21) International Application Number: PCT/US97/06324

(22) International Filing Date: 15 April 1997 (15.04.97)

(30) Priority Data:  
08/633,241 16 April 1996 (16.04.96) US

(71) Applicant: NATIONAL FOAM, INC. [US/US]; 150 Gordon Drive, Lionville, PA 19353 (US).

(72) Inventor: BAKER, Kenneth, C.; Unit H-48, 700 Farmington Avenue, Pottstown, PA 19464 (US).

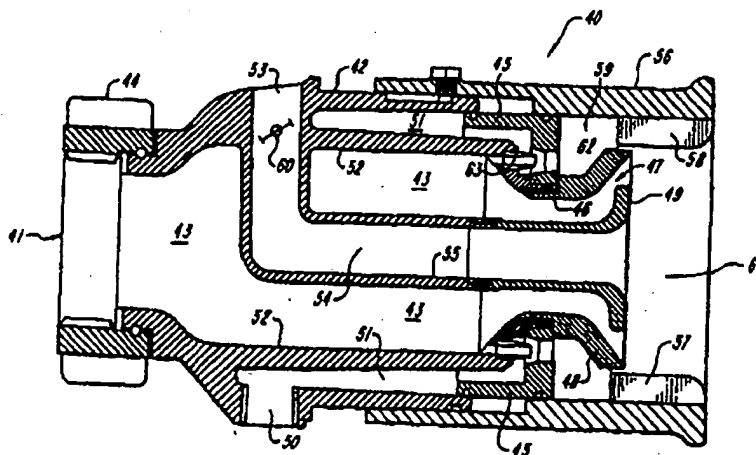
(74) Agents: CONNORS, Matthew, E. et al.; Samuels, Gauthier, Stevens &amp; Reppert, Suite 3300, 225 Franklin Street, Boston, MA 02110 (US).

(81) Designated States: AU, BR, CA, CN, MX, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

## Published

*With international search report.**Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.*

(54) Title: NOZZLE FOR USE WITH FIRE-FIGHTING FOAMS



## (57) Abstract

A nozzle assembly including a nozzle body having an inlet at a first end and an outlet at a second end. A first fluid passageway is defined within the nozzle body for first fluids passing between the inlet and outlet. Second and third fluid passageways for respective second and third fluids are also defined within said nozzle body. A discharge mixing unit is provided at the second end and is in fluid communication with the first, second and third fluid passageways for mixing the first, second and third fluids to produce a discharge solution. The discharge mixing unit includes one or more mixing chambers provided on the interior surface of the second end of the nozzle body. The mixing chambers are defined between a plurality of inwardly extending blades from the interior surface of the second end. The second end of the nozzle body has an adjustably extending pattern selection sleeve. The third passageway includes a variable fluid flow control device which is operable for varying the expansion ratios of the discharge solution.

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

## NOZZLE FOR USE WITH FIRE-FIGHTING FOAMS

### BACKGROUND OF THE INVENTION

In the design and operation of air-foam nozzles of the type used for flammable liquid firefighting, there are a number of problems that must be solved. Over the years many nozzles have been developed attempting to overcome one, or  
5 more, of the following problems: (1) provide a simple means to inject firefighting foam concentrates into the water stream at the nozzle; (2) provide a means to insure thorough mixing of water and foam concentrate within the nozzle; (3) provide a means to control the amount of air entrained into  
10 the water-foam solution; and (4) provide a means of increasing the discharge range of aerated foam solution.

Conventional air-foam nozzles can easily be divided into two broad groups based on the "expansion ratio" of the nozzle. "Expansion ratio" is a term describing the final  
15 volume of air-foam bubbles when compared to the original volume of foam solution. As the expansion ratio of a foam sample increases, it indicates a greater ability of the nozzle to mechanically agitate and aerate the foam solution. A nozzle with a higher expansion ratio generates foam having  
20 a lighter weight per unit of volume, with smaller, more homogeneous, thinner-walled bubbles which are longer lasting due to their greater ability to retain foam liquid in the bubbles.

Air-foam nozzles designed for use with synthetic based  
25 foam concentrates know as aqueous film forming foams (AFFF) customarily have low expansion ratios, less than 4 to 1. AFFF foams are very effective on flammable liquid spill fires, and were originally developed for aircraft crash firefighting, where a rapidly spreading, low expansion foam  
30 blanket is preferred to give rapid knockdown of flames so that passengers and crew can be quickly rescued from a burning aircraft. This effectiveness is due in large part to an aqueous film that spreads on the surfaces of the flammable liquid as the foam bubbles break, thereby slowing  
35 vaporization from the surface of the liquid and helping prevent re-ignition. A low expansion, quick draining foam

.. 2 ..

is preferred for this application.

Nozzles designed for use with AFFF concentrates may be subdivided into two additional types: (1) those in which foam solution is pumped to the nozzles through fire hose or piping as shown by the nozzle 10 of Figs. 1A and 1B; and (2) those where foam solution is formed in the nozzle by water being pumped to the nozzle through fire hose or piping and foam concentrate being supplied to the nozzle through a separate conduit as shown by the nozzle 20 of Figs. 2A and 10 2B.

In nozzles where foam solution is pumped to the nozzle as in the nozzle 10 of Figs. 1A and 1B, water and concentrate have ample time for thorough mixing while traveling through the hose or piping. In nozzles where the 15 water and foam concentrate must mix at the nozzle as in the nozzle 20 of Figs. 2A and 2B, mixing may not be uniform, especially if the concentrate is injected on the inside of the cylinder formed by the water discharge.

This non uniform distribution of foam concentrate in 20 the water stream will have a negative impact on the foam quality produced by the nozzle. The foam bubbles will not be uniform in size and as a result the expanded (aerated) foam will deteriorate rapidly. Foam with rapid deterioration (typically called fast draining) is not 25 optimized and therefore is not likely to be suitable for the intended application.

Air can only be entrained on the outer surface of the discharge pattern when either type nozzle is adjusted at or near the straight stream setting as shown in Figs. 1A and 2A 30 when a pattern selection sleeve 12, 22 is adjusted to the outward position. This limited aeration results in low expansion ratios. Lower expansion foam is heavier than foam with higher expansion ratios, and generally has a greater ability to travel through the air over longer distances for 35 a given discharge velocity.

Nozzles designed for use with protein based foam concentrates are of the air-aspirating type. Exemplary nozzles 30 and 32 are shown in Figs. 3A and 3B,

- 3 -

respectively. These nozzles have expansion ratios greater than 6 to 1. Protein based foam concentrates require more energy than do synthetic based concentrates for aeration of the foam solution into expanded fire-fighting foam. Protein based foams depend on a thick blanket of bubbles, not an aqueous film, for extinguishment.

These nozzles may also be subdivided into two additional types: (1) those in which foam solution is pumped to the nozzle through fire hose or piping as shown in Fig 3A; and (2) those where water is pumped to the nozzle through fire hose or piping and foam concentrate is supplied to the nozzle through a separate conduit as shown in Fig. 3B.

Nozzles with the ability to pick up concentrate through a separate conduit by use of a built-in-venturi as shown in Fig. 3B have been in widespread use since they were developed in the 1940's. These "self educting" nozzles offer good mixing of the water and foam concentrate, however, the kinetic energy required to assure good mixing and air aspiration reduces the velocity of the discharge stream, thereby shortening the discharge range that can be achieved. On the other hand, nozzles of the variable-pattern fog type with a built-in venturi as shown in Figs. 2A and 2B, do not offer mixing as good as the air-aspirating type, but because they use less kinetic energy for mixing and air-aspiration their discharge range is enhanced.

Existing nozzles with a built-in means of foam concentrate pick-up as shown in Figs. 2A, 2B and 3B are all designed so that concentrate enters through a conduit in the side of the nozzle. This conduit then typically connects with a conduit along the central axis of the nozzle bore and inside the main waterway. The conduit may be equipped with a venturi suction chamber, or the end of the conduit may be sealed. If the concentrate conduit is sealed on the inlet end of the nozzle, concentrate must be pumped to the nozzle by a separate pump which could be of the water powered venturi type. Although designs may differ,

the basic principle has remained unchanged since its inception.

### SUMMARY OF THE INVENTION

5 It is therefore an object of the present invention to provide a single firefighting nozzle design addressing all four of these problem areas. The invention discharges a solution consisting of fresh, brackish, or sea water, mixed with small amounts of firefighting foam concentrate. This  
10 solution is then aerated to form expanded firefighting foam suitable for use by those skilled in the flammable liquid firefighting art. The characteristics of the fire or hazard determine the type and percent concentration of the foam concentrate used, the desired foam expansion ratio, and the  
15 type discharge device selected.

Accordingly, the present invention provides a nozzle assembly including a nozzle body having an inlet at a first end and an outlet at a second end. A first fluid passageway is defined within the nozzle body for first fluids passing  
20 between the inlet and outlet. Second and third fluid passageways for respective second and third fluids are also defined within said nozzle body. A discharge mixing unit is provided at the second end and is in fluid communication with the first, second and third fluid passageways for  
25 mixing the first, second and third fluids to produce a discharge solution. The discharge mixing unit includes one or more mixing chambers provided on the interior surface of the second end of the nozzle body. The mixing chambers are defined between a plurality of inwardly extending blades  
30 from the interior surface of the second end. The second end of the nozzle body has an adjustably extending pattern selection sleeve. The third passageway includes a variable fluid flow control device which is operable for varying the expansion ratios of the discharge solution.

35

### BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A and 1B show cross sections of a conventional nozzle with a pattern selection sleeve adjusted outwardly

for straight stream discharge and inwardly for fog stream discharge, respectively;

Figs. 2A and 2B show cross sections of a conventional nozzle using a separate foam concentrate conduit with a pattern selection sleeve adjusted outwardly for straight stream discharge and inwardly for fog stream discharge, respectively;

Fig. 3A shows a cross section of a conventional aspirating nozzle in which a foam solution is supplied to the nozzle; Fig. 3B shows a cross section of a conventional aspirating nozzle in which water and foam concentrate are supplied to the nozzle via different conduits;

Fig. 4 shows a cross section of a nozzle in accordance with the present invention having a pattern selection sleeve adjusted outwardly for straight stream discharge;

Fig. 5 shows a cross section of the nozzle of Fig. 4 in a disassembled state;

Fig. 6 shows a frontal view of the nozzle of Fig. 4 taken along line 4-4; and

Fig. 7 shows an exploded cross section view of the jet nozzles and discharge tube assembly openings from the nozzle of Fig. 4.

#### DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

An exemplary nozzle 40 in accordance with the present invention is shown in Figs. 4-6. The nozzle 40 includes a nozzle body 42 having a feed-in conduit 41 and an internal main waterway 43. A swivel inlet coupler 44 accommodates the attachment of the nozzle to a desired source, e.g. hose, of water or foam.

In accordance with an exemplary embodiment of the present invention, water is pumped through the conduit 41 to the base of the nozzle where it flows into the main waterway 43. The main waterway has therein a discharge tube assembly 45 which changes having a central short cylindrical tube opening 46 that curves outward to an annular orifice 47 formed by a nozzle discharge head 48 and a baffle plate 49. The discharge tube assembly 45 is held in place by the

- 6 -

discharge head 48 when the discharge head is screwed into the nozzle body.

The discharge tube assembly 45 includes a plurality of discharge openings 62. Fluid from the main waterway 43 is fed to the openings 62 via a plurality of jet nozzles 63. The interaction between the jet nozzles and openings serving as a jet pump will be described in more detail hereinafter.

A first conduit 50 in the nozzle body communicates with a chamber 51, which is concentrically defined around the outside of the main waterway 43. A coaxially displaced cylindrical wall 52 is positioned within the nozzle body in order to separate the main waterway 43 and chamber 51. In accordance with an exemplary embodiment of the present invention, the conduit 50 serves as an entryway for foam concentrate to the nozzle.

A second conduit 53 in the nozzle body communicates with a chamber 54, which is concentrically defined within the main waterway 43. A coaxially displaced tube 55 is positioned within the nozzle body in order to separate the main waterway 43 and chamber 54. The tube 55 extends through the main waterway and through the discharge head 48, and includes an outwardly flared end which defines the baffle plate 49. In accordance with an exemplary embodiment of the present invention, the conduit 53 serves as an entryway for air to the nozzle.

The nozzle body also includes an adjustable pattern selection sleeve 56. The pattern selection sleeve is slidable between a fully extended outward position as shown which promotes straight stream discharge of fluids from the nozzle, and an inward position which promotes fog stream discharge of fluids from the nozzle.

In accordance with the present invention, a plurality of blades 57 extend radially outwardly from the inner circumferential end surface of the pattern selection sleeve 56. The plurality of blades 57 in turn define a plurality of mixing chambers 58 therebetween. The mixing chambers are in fluid communication with both the main waterway 43 and the chamber 51 associated with the first conduit 50 via a



- 7 -

chamber 59. The chamber 59 is defined between the inner surface of the pattern selection sleeve 56 and the discharge head 48.

The nozzle configuration shown in Fig. 4 gradually increases the velocity head of the water stream, thereby decreasing the pressure head. In the situation where a water stream from the main waterway 43 passes through the annular orifice 47 and is discharged to atmosphere, all of the available kinetic energy has been converted to velocity head. Water passes over the outer edge of the discharge head 48 and enters the multiple mixing chambers 58 formed by the blades 57 on the pattern selection sleeve. Within the mixing chambers 58, the water mixes with foam concentrates flowing from conduit 50 and chamber 51.

With reference now to Fig. 7, a more detailed description of the jet pump action of the openings 62 and jet nozzles 63 is provided. The jet nozzle 63 includes an inlet 70 for fluid communication with the main waterway 43. A suction chamber 71 is defined at the outlet of the nozzle jet and the opening 62, which in turn are in fluid communication with the chamber 51. The opening 62 includes a cylindrical parallel section 72 which feeds to a diffuser/discharge area 73 which coincides with earlier described chamber 59.

The ability of the jet pump formed by jet nozzles 63 and opening 62 to educt a fluid is based on the same principle found in all nozzles of the self educting type. This same principle is used in air aspirating nozzles to pick up air and aspirate the foam solution. The inlet 70 is the area where fluid enters the jet pump nozzle. The suction chamber 71 is an area where fluid being pumped enters the jet pump, and where high velocity fluid from the jet pump nozzle entrains fluid being pumped from suction. The parallel section 72 is an area where fluid being pumped mixes with fluid from the jet pump nozzle, thereby acquiring energy from the nozzle discharge. The diffuser/discharge area is an area where fluids loose velocity pressure and regain static pressure due to velocity change so that fluids

- 8 -

can enter pressurized area in the mixing chambers 58 formed by the blades 57.

According to a preferred embodiment, it is critical that the included angle of the discharge head 49 is 90° or less. If this included angle is greater, pressure rises excessively in chamber 59 so that the jet pumps are no longer capable of operating. The jet pumps will operate up to a back pressure equal to 10% of the nozzle operating pressure, and if the included angle is greater than 90°, the back pressure in chamber 59 will exceed this 10% limit.

With reference back to Figs. 4-6, a variable air flow control device 60, e.g. a conventional air flow valve, may be opened to allow air to flow through the conduit 53 and chamber 54 along the nozzle axis. Air exits the central chamber 54 into a low pressure area 61 which exists behind the baffle plate 49 at the end of the tube 55. The low pressure area 61 is created by water flow out of the annular orifice 47 being deflected by the pattern selection sleeve 56 to flow parallel, or nearly so, to the axis of the nozzle. Air enters mixing chambers 58 and mixes with the foam solution to form finished foam for discharge.

The variable air flow control device 60 may be closed completely to provide lower expansion ratios when AFFF foams are used for spill fires. Alternatively, the air flow control device may be fully opened to provide higher expansion ratios when protein based foams are used.

In situations where foam solution is pumped to the nozzle feed-in conduit 41 through the main waterway 43, it is not necessary to use the conduit 50 and chamber 51 for entering foam concentrate to the nozzle. Instead, the conduit 50 and chamber 51 can be used for additional aeration. In this manner, air is allowed enter the chamber 51, where it can flow through the chamber 59 into the mixing chambers 58, thus allowing greater aeration and higher expansion ratios for the discharged foam solution.

Accordingly, the present invention provides a firefighting nozzle for use in flammable liquid firefighting and has a unique combination of benefits not available in

- 9 -

conventional nozzle designs. The invention combines several desirable characteristics in a cost effective design. For example, when adjusted at or near the straight stream patterns, aeration takes place on the outside of the stream 5 as in existing nozzles, but the unique central air passage allows the option of selecting higher expansion ratios by allowing air to enter the low pressure area created inside the discharge pattern.

The use of the blades 57 located on the inside of the 10 outer pattern selection sleeve 56 serve multiple functions. The blades act as straightening vanes to cancel the twisting currents developed inside the nozzle and the negative effect these currents have on the discharge pattern, thus tending to increase the discharge range capability with aerated 15 foams. The blades 57 separate the discharge area into the plurality of mixing chambers 58 to enhance mixing of the water and foam concentrate when the liquids must mix in the nozzle. The separate mixing chambers formed by the blades allow greater agitation and aeration of the solution when 20 the central airway is opened and the nozzle is adjusted at, or near the straight stream pattern. If foam solution is pumped to the nozzle and the concentrate chamber around the main conduit is left open to atmosphere, more air enters the mixing chambers formed by the blades and additional aeration 25 occurs.

Furthermore, when water and foam concentrate are supplied through separate conduits, good mixing will occur in the mixing chambers, regardless of the pattern selected.

The foregoing description has been set forth to 30 illustrate the invention and is not intended to be limiting. Since modifications of the described embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the scope of the invention should be limited solely with reference to the 35 appended claims and equivalents thereof. What is claimed is:

- 10 -

CLAIMS

- 1        1. A nozzle assembly (40) comprising:  
2        a nozzle body (42) having an inlet (41) at a first end  
3 and an outlet at a second end;  
4        a first fluid passageway (43) defined within said  
5 nozzle body for first fluids passing between said inlet and  
6 outlet;  
7        a second fluid passageway (51) for second fluids  
8 defined within said nozzle body;  
9        a third fluid passageway (54) for third fluids defined  
10 within said nozzle body; and  
11        discharge mixing means (45-48, 56-59) provided at said  
12 second end and in fluid communication with said first,  
13 second and third fluid passageways for mixing said first,  
14 second and third fluids to produce a discharge solution.
- 1        2. The nozzle assembly of claim 1, wherein said first  
2 fluid passageway is defined by a first wall within said  
3 nozzle body extending between said first end and said second  
4 end.
- 1        3. The nozzle assembly of claim 2, wherein said second  
2 fluid passageway is defined between said first wall and a  
3 second wall positioned inwardly from said first wall and  
4 within said first passageway, said second fluid passageway  
5 surrounding said second wall and said first fluid  
6 passageway.
- 1        4. The nozzle assembly of claim 3, wherein said third  
2 fluid passageway is defined between said second wall and a  
3 third wall positioned inwardly from said second wall and  
4 within said first fluid passageway, said first fluid  
5 passageway surrounding said third wall and said third fluid  
6 passageway.
- 1        5. The nozzle assembly of claim 1, wherein said  
2 discharge mixing means comprises at least one mixing chamber  
3 provided on the interior surface of said second end of said

- 11 -

4 nozzle body.

1        6. The nozzle assembly of claim 5, wherein said at  
2 least one mixing chamber is defined between a plurality of  
3 inwardly extending blades from the interior surface of said  
4 second end.

1        7. The nozzle assembly of claim 6, wherein said second  
2 end of said nozzle body comprises an adjustably extending  
3 pattern selection sleeve.

1        8. The nozzle assembly of claim 1, wherein said third  
2 passageway comprises a variable fluid flow control device  
3 which is operable for varying the expansion ratios of said  
4 discharge solution.

1        9. The nozzle assembly of claim 1, wherein said first  
2 fluid comprises water, said second fluid comprises foam  
3 concentrate, and said third fluid comprises air.

1        10. The nozzle assembly of claim 1, wherein said first  
2 fluid comprises foam solution and said second and third  
3 fluids comprise air.

1        11. A nozzle assembly comprising:  
2        a nozzle body having an inlet at a first end and an  
3 outlet at a second end;  
4        a plurality of fluid passageways defined within said  
5 nozzle body for respectively passing a plurality of fluids  
6 through said nozzle body to said second end; and  
7        discharge mixing means provided at said second end and  
8 in fluid communication with said plurality of fluid  
9 passageways for mixing said plurality of fluids to produce  
10 a discharge solution, said discharge mixing means comprises  
11 a plurality of mixing chambers positioned on the interior  
12 surface of said second end of said nozzle body.

1        12. The nozzle assembly of claim 11, wherein said

.. 12 ..

2 plurality of mixing chambers are defined between a plurality  
3 of inwardly extending blades from the interior surface of  
4 said second end.

1        13. The nozzle assembly of claim 12, wherein said  
2 second end of said nozzle body comprises an adjustably  
3 extending pattern selection sleeve.

1        14. The nozzle assembly of claim 11, wherein said  
2 plurality of fluid passageways comprises first, second and  
3 third fluid passageways for respectively passing first,  
4 second and third fluids through said nozzle body.

1        15. The nozzle assembly of claim 14, wherein said  
2 first fluid passageway is defined by a first wall within  
3 said nozzle body extending between said first end and said  
4 second end.

1        16. The nozzle assembly of claim 15, wherein said  
2 second fluid passageway is defined between said first wall  
3 and a second wall positioned inwardly from said first wall  
4 and within said first passageway, said second fluid  
5 passageway surrounding said second wall and said first fluid  
6 passageway.

1        17. The nozzle assembly of claim 16, wherein said  
2 third fluid passageway is defined between said second wall  
3 and a third wall positioned inwardly from said second wall  
4 and within said first fluid passageway, said first fluid  
5 passageway surrounding said third wall and said third fluid  
6 passageway.

1        18. The nozzle assemb. of claim 14, wherein said  
2 third passageway comprises a variable fluid flow control  
3 device which is operable for varying the expansion ratios of  
4 said discharge solution.

1        19. The nozzle assembly of claim 14, wherein said

- 13 -

2 first fluid comprises water, said second fluid comprises  
3 foam concentrate, and said third fluid comprises air.

1        20. The nozzle assembly of claim 14, wherein said  
2 first fluid comprises foam solution and said second and  
3 third fluids comprise air.

1        21. A method of producing a discharge solution in a  
2 nozzle assembly, said nozzle assembly including a nozzle  
3 body having an inlet at a first end and an outlet at a  
4 second end, said method comprising:

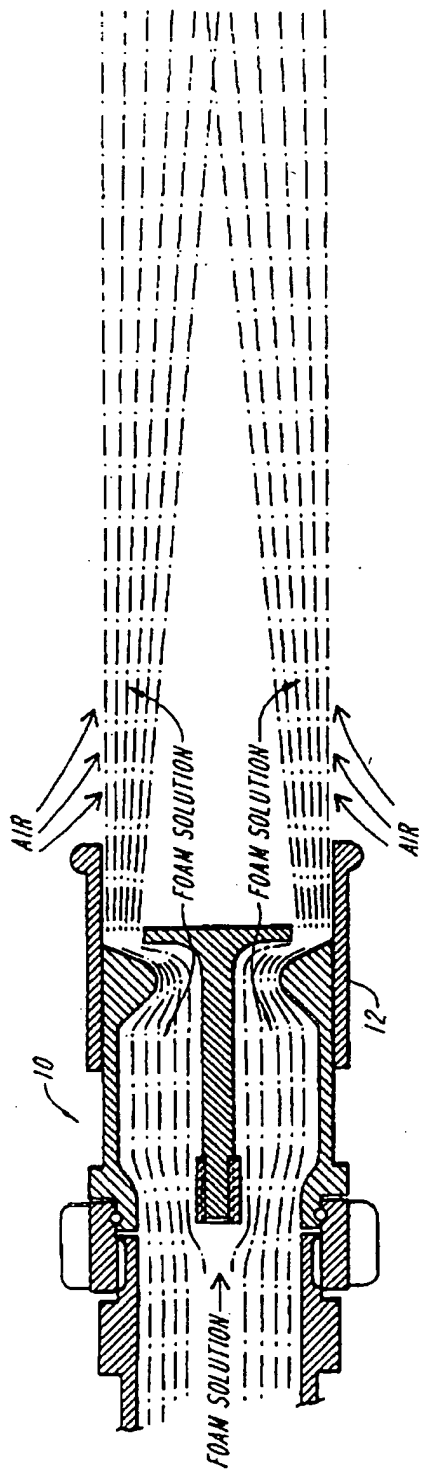
5        passing a first fluid through a first fluid passageway,  
6 said first fluid passageway defined within said nozzle  
7 between said inlet and outlet;

8        passing a second fluid through a second fluid  
9 passageway, said second fluid passageway defined within said  
10 nozzle body;

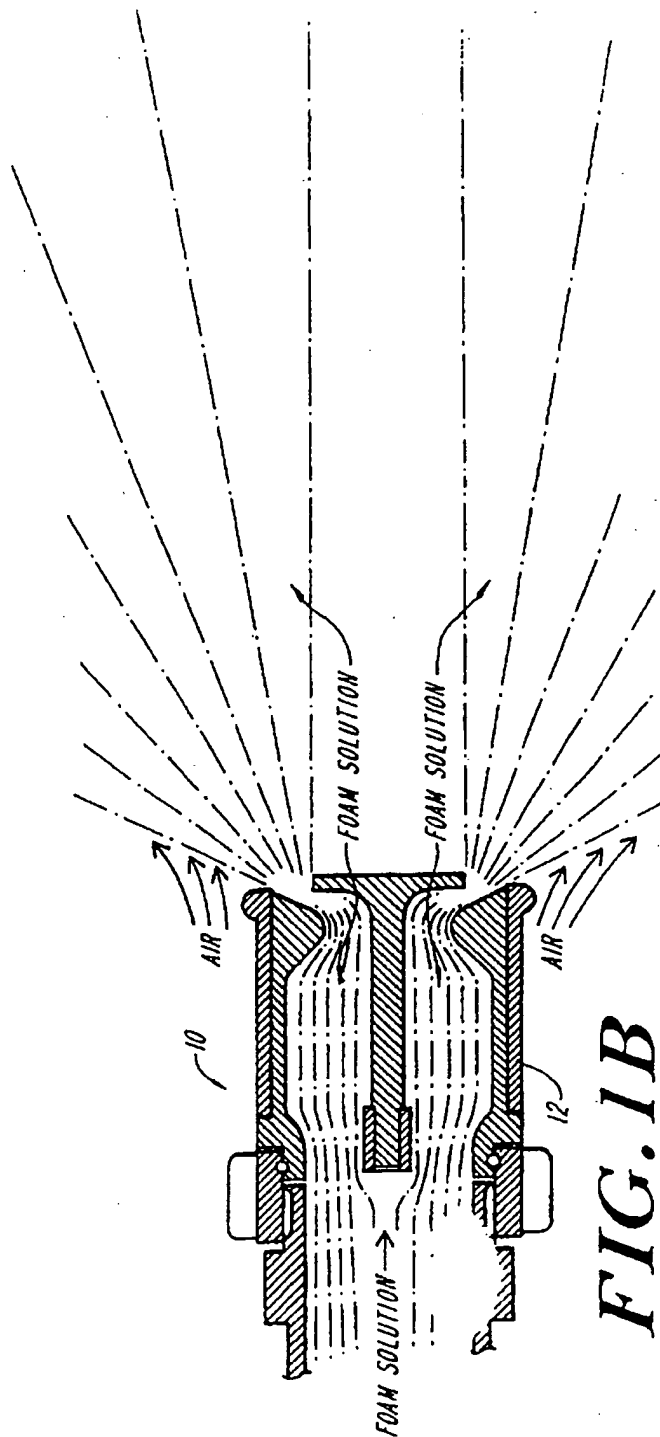
11       passing a third fluid through a third fluid passageway,  
12 said third fluid passageway defined within said nozzle body;  
13 and

14       mixing said first, second and third fluids to produce  
15 said discharge solution within mixing chambers at said  
16 second end of said nozzle body.

117

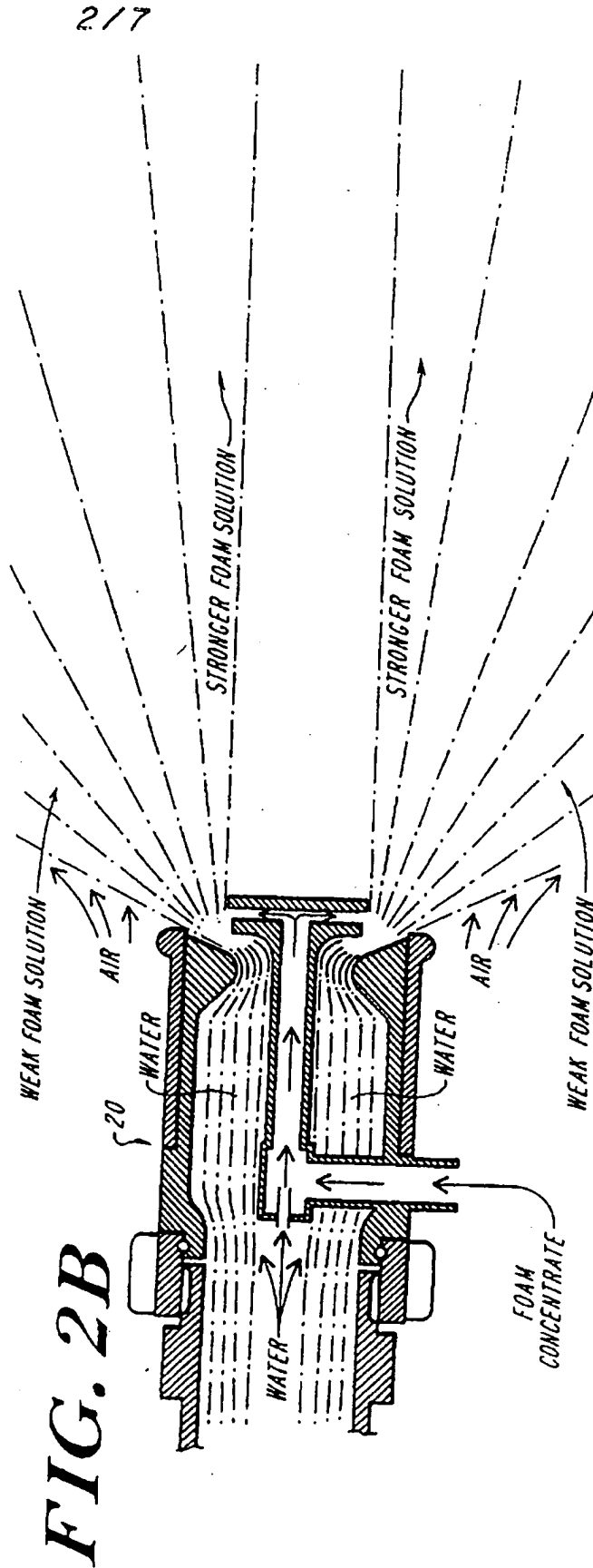
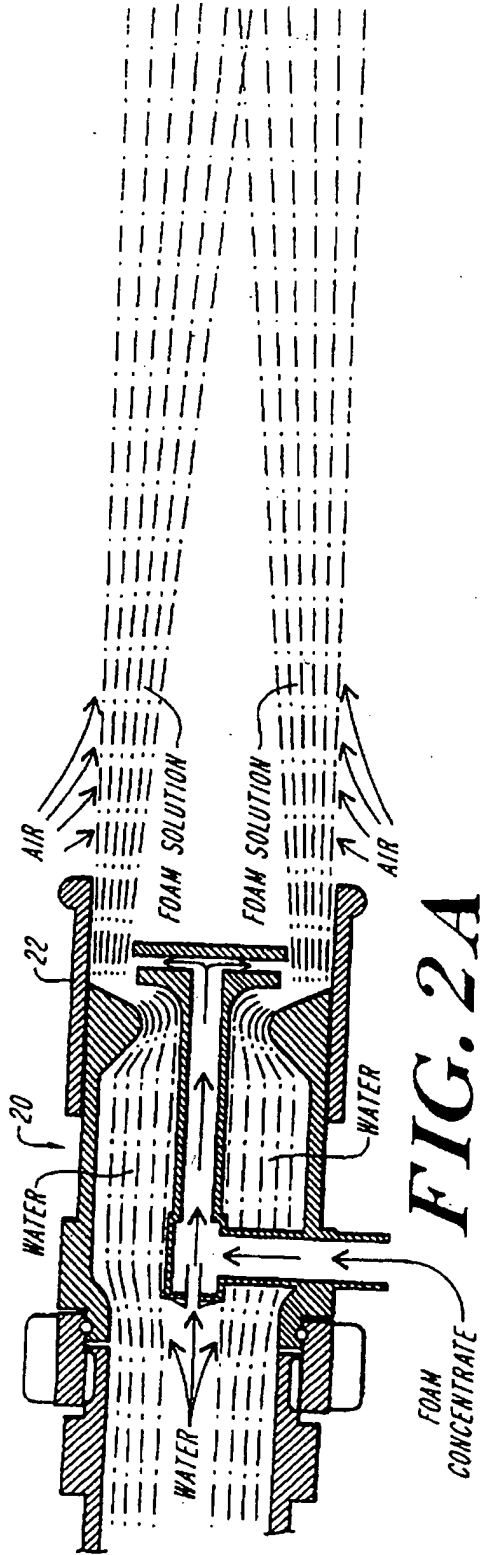


**FIG. 1A**



**FIG. 1B**





3/7

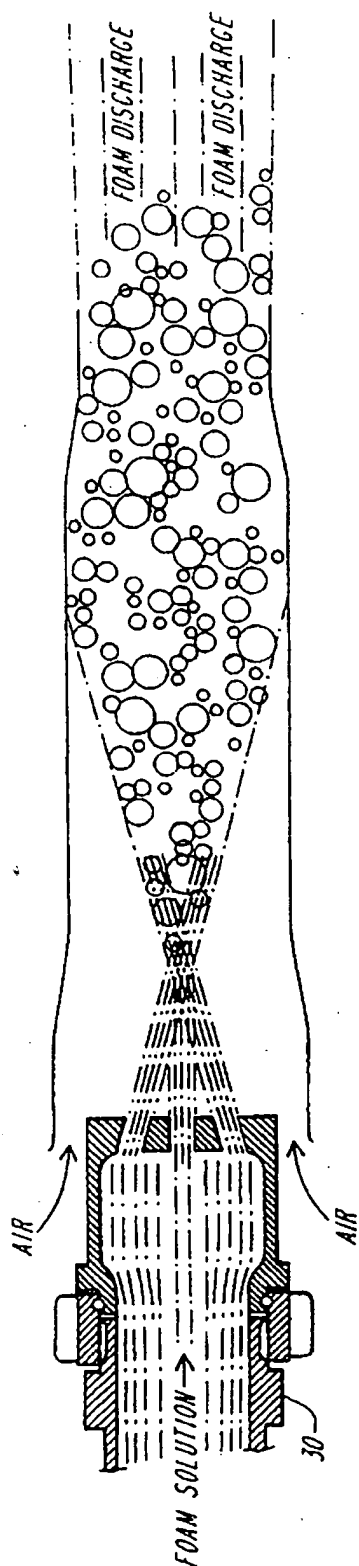


FIG. 3A

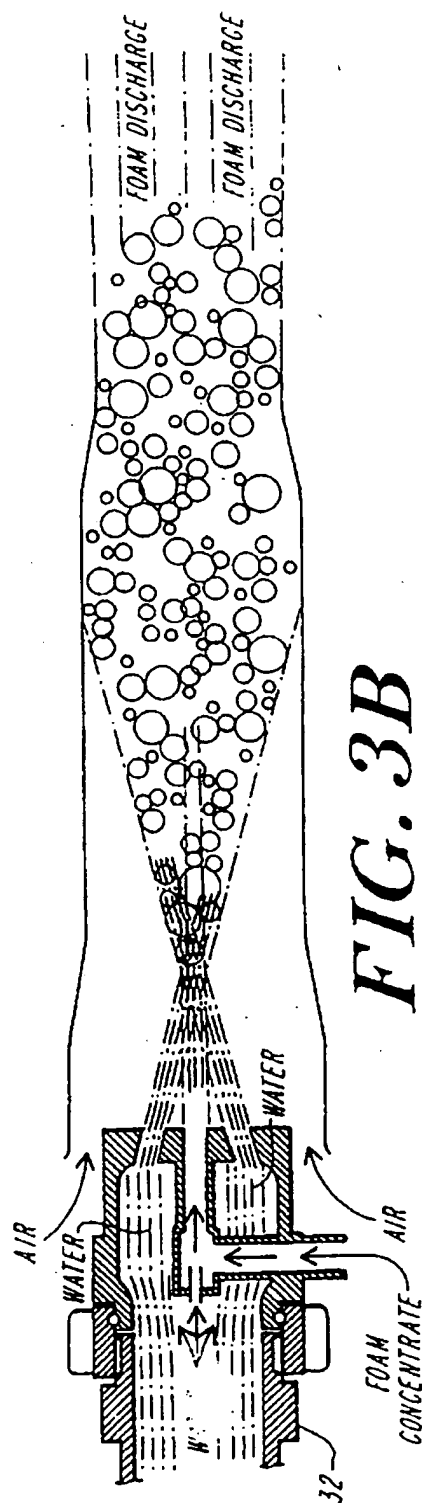


FIG. 3B

4/7

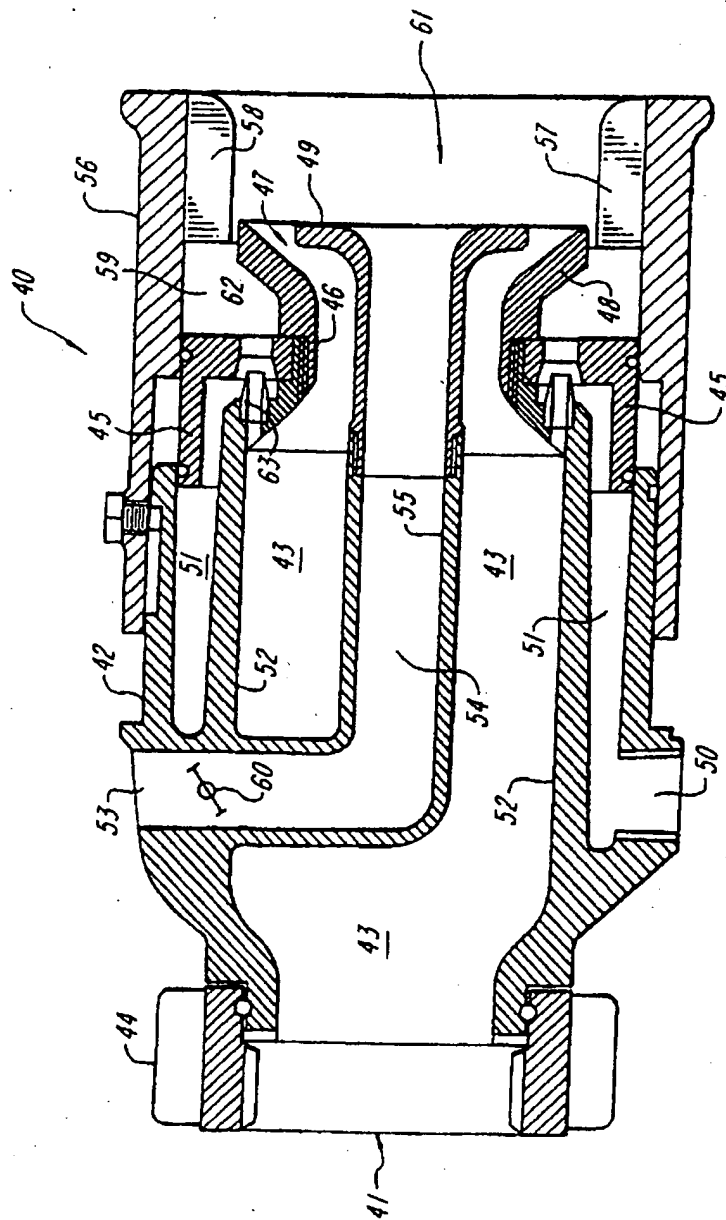


FIG. 4

5/7

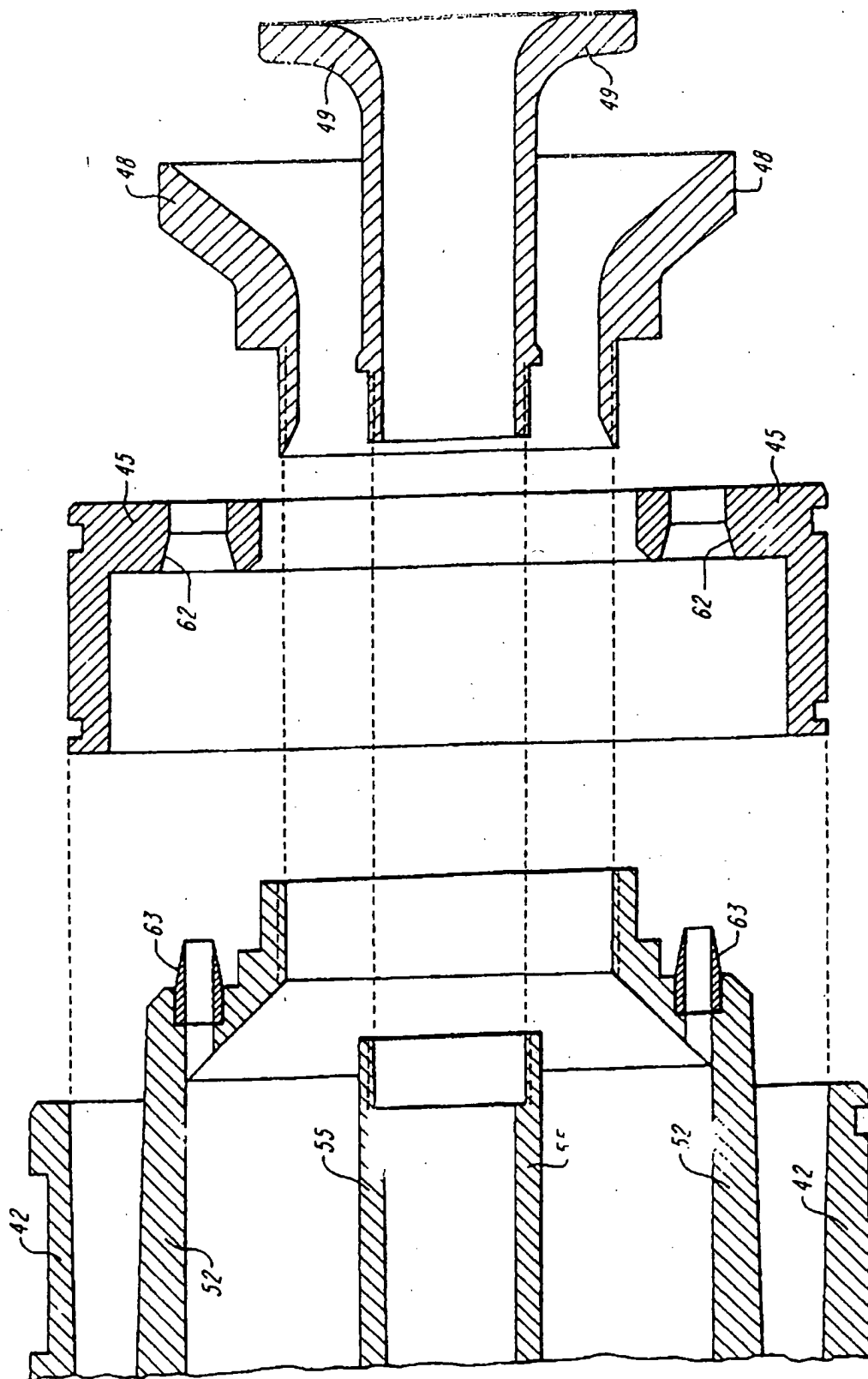
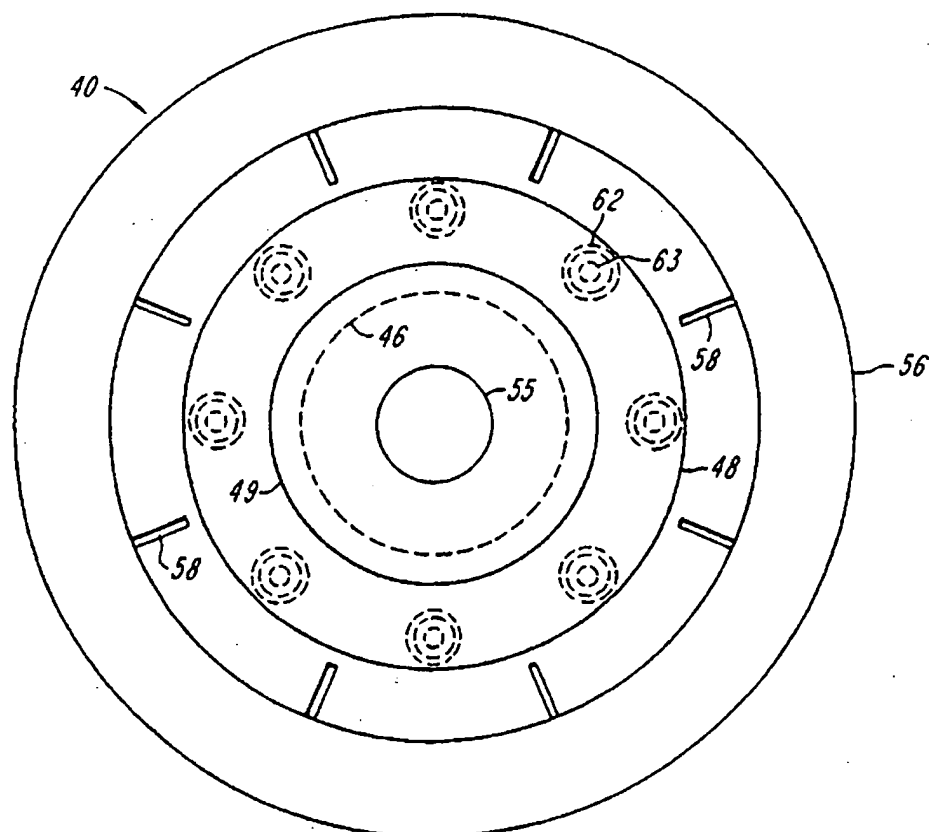


FIG. 5

6 / 7



**FIG. 6**

7/7

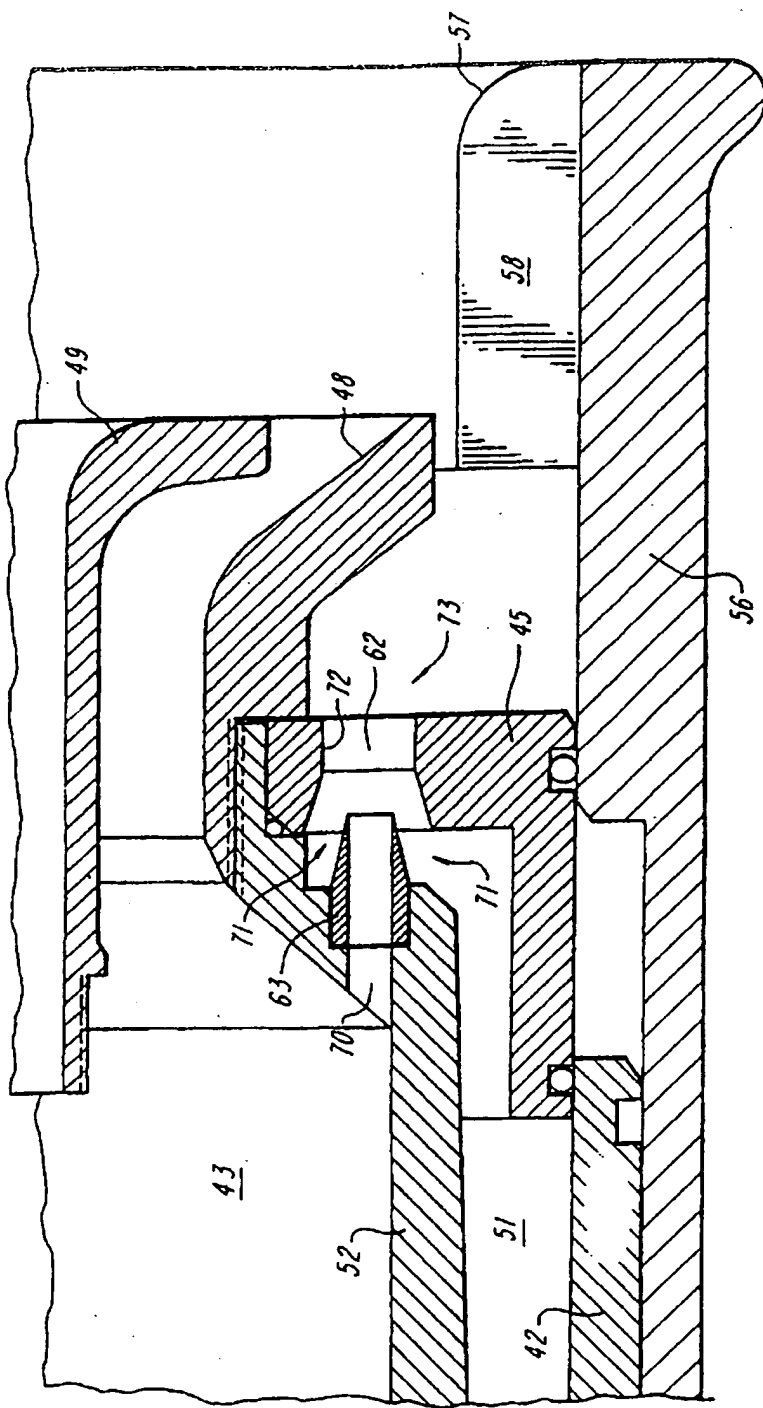


FIG. 7

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 97/06324

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 6 A62C31/12 B05B7/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
 IPC 6 A62C B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 608 140 A (CCA INC) 27 July 1994	1-5, 9-12, 14-17, 19-21 6,7,13
Y	see column 5, line 15 - column 10, line 17; figures	
Y	EP 0 099 626 A (CCA INC) 1 February 1984 see page 7, line 30 - page 8, line 13; figures	6,7,13
X	EP 0 429 736 A (LE GROUYELLEC) 5 June 1991	1-5, 9-12, 14-17, 19-21 7,13
Y	see column 2, line 37 - column 5, line 3; figures	
	---	
	--- -/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

- \* "A" document defining the general state of the art which is not considered to be of particular relevance
- \* "E" earlier document but published on or after the international filing date
- \* "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \* "O" document referring to an oral disclosure, use, exhibition or other means
- \* "P" document published prior to the international filing date but later than the priority date claimed

\* "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\* "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\* "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

\* "&" document member of the same patent family

Date of the actual completion of the international search

5 August 1997

Date of mailing of the international search report

14.08.97

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
 NL - 2280 HV Rijswijk  
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
 Fax (+31-70) 340-3016

Authorized officer

Triantaphillou, P

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 97/06324

## C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 505 100 A (CCA INC) 23 September 1992 see column 3, line 58 - column 6, line 26; figures	7,13
A	EP 0 399 646 A (CCA INC) 28 November 1990 -----	



## INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 97/06324

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 608140 A	27-07-94	US 5575341 A	19-11-96
EP 99626 A	01-02-84	AU 555644 B	02-10-86
		AU 8944682 A	19-01-84
		US 4828038 A	09-05-89
		US 4640461 A	03-02-87
EP 429736 A	05-06-91	FR 2636545 A	23-03-90
EP 505100 A	23-09-92	US 5167285 A	01-12-92
		AT 131082 T	15-12-95
		AU 645942 B	27-01-94
		AU 1299392 A	24-09-92
		CA 2062864 A	22-09-92
		DE 69206454 D	18-01-96
		DE 69206454 T	18-07-96
		ES 2084274 T	01-05-96
		JP 5115576 A	14-05-93
		US 5275243 A	04-01-94
EP 399646 A	28-11-90	US 5012979 A	07-05-91
		AT 115423 T	15-12-94
		AU 621264 B	05-03-92
		AU 5365190 A	01-11-90
		DE 69014996 D	26-01-95
		DE 69014996 T	04-05-95
		ES 2065485 T	16-02-95